DOCUMENT RESUME

ED 248 651 EC 170 430

AUTHOR Blake, Rowland S.
TITLE Discovery versus Expository Instructional Strategies and Their Implications for Instruction of Hearing-Impaired Post-Secondary Students.
PUB DATE Jun 84
NOTE 50p.; In: Areson, Ann H., Ed. and DeCaro, James J., Ed. Teaching, Learning and Development: Volume I. See EC 170 424.
PUB TYPE Reports - Research/Technical (143) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Career Development; Deafness; *Discovery Learning; Discovery Processes; Educational Strategies; *Hearing Impairments; Learning Processes; *Lecture Method; Postsecondary Education; *Teaching Methods
IDENTIFIERS *Expository Teaching

ABSTRACT

Part of a collection of papers commissioned by Foundations, a project designed to identify career development needs of students entering the National Technical Institute for the Deaf (NTID), the paper examines implications of discovery and expository learning for hearing impaired students. Differences are considered between the discovery metnod, which centers on the student's learning processes rather than outcomes and the expository method, which focuses more on the teacher as the information supplier. Claims for discovery learning (e.g., that it enhances problem solving and promotes transfer) are summarized. Disagreement over the meaning or implementation of a discovery approach is cited as one of the reasons that research studies comparing the effects of the discovery method and expository instruction have been inclusive. Tentative conclusions are reviewed concerning the following variables: immmediate retention, transfer, time for learning, motivation, amount of guidance, and verbalization of rule. Research is also reviewed on the relationship of instructional methods to learner characteristics (mental ability, field dependence/independence, aptitudes and interests, creativity, age, anxiety) and content characteristics (difficulty of learning and transfer tasks, previous knowledge, category of learning in cognitive domain, domains of learning, content areas, and language teaching). The paper concludes with sets of general and specific recommendations for career education at NTID. (CL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.
Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED248651

Discovery versus Expository Instructional Strategies and Their Implications for Instruction of Hearing-Impaired Post-Secondary Students

Rowland S. Blake

EC170430

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Rowland Blake

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

A Historical Perspective

"...to really possess knowledge or acquire an idea, the learner must discover by himself or through his own insight." (Quotation in Ausubel, 1978, p. 529)

This reflects the views of many eminent individuals who have argued for the virtues of "discovery learning." Discovery learning occurs when a person discovers a concept or principle among concrete phenomena or examples rather than being given a statement of that concept or principle. It focuses on the learner and the learning process, although exponents of this method have typically been educators encouraging teachers to promote discovery through their teaching. This method is thus not only a learning method, but an instructional one as well, since the teacher consciously withholds pertinent information to promote discovery by the learner, often providing certain cues or prompts to the learner in order to promote learning.

The discovery method has found proponents from very early times. In his dialogue with the slave boy, Socrates engaged in posing questions to the boy in order to help him discover certain principles of geometry.

Other prominent proponents of the discovery method have been Rousseau, Montessori, Dewey, and Bruner (Kornbau, 1977). Advocacy for the discovery method grew especially in the wake of the Progressive Education movement, which viewed traditional teaching as authoritarian and heavily abstract. At that time the common image of teaching tended to be that of the professor standing at the front of the class, dispensing truth in the form of factual information and generalities within the context of a lecture. In reaction to that perception of traditional methods, other approaches utilizing laboratory work, concrete experiences, and problem solving tasks were recommended. Focus was turned on children's individual needs and their capacity to discover things for themselves. This trend received an additional boost from the growing cry for increased

scientific competence for American students in the post-Sputnik era. The scientific laboratory at schools and colleges grew in prominence and students were encouraged to engage in discovery experiences in order to be "scientific."

The most prominent advocate for discovery learning in recent times has been Jerome S. Bruner. He has done more to popularize discovery learning than probably any other educator. He argues persuasively for the benefits that discovery learning can give, advancing a number of arguments which tend to be philosophical, but which ultimately are subject to empirical verification.

Probably one of Bruner's greatest contributions has been to provoke overt experimentation in order to establish the validity of the discovery method. The decade of the 1960's saw a fair amount of experimentation, which lasted into the 1970's. In recent years, experimental interest in the topic has waned, probably due to the relative lack of conclusive research findings on the question. More recent research on the discovery method has shifted away from the question about the utility of the discovery method as a unified approach, and has centered more on establishing interactions--the various conditions under which the discovery method may be valuable, for example, for certain types of students, certain types of content, or certain types of learning tasks. Before examining such research studies and their results, let us first define as accurately as possible just what the discovery method is.

Discovery Method and Expository Method

In order to understand how the discovery and expository methods differ, it is first necessary to understand various categories of learning behavior and specifically, what a "rule" is.

Domains and Categories of Learning Behavior

In an effort to define different types of learning and to formulate learning and/or instructional strategies for each type or category of learning behavior, various educators have developed taxonomies of learning behaviors.

Bloom (1956) divides behaviors into the cognitive domain (intellectual processes), the psychomotor domain (motor skills), and the affective domain (attitudes and values). Each of the domains can be broken down further into types of learning. Here are some of the most prominent types found in the cognitive domain (adapted from Gagne, 1970, 1977):

Categories of Learning in the Cognitive Domain

Learning Category	Example
Memorized knowledge	Stating that Gutenberg was the first person to use movable type to print a book
Discrimination	Distinguishing printed b's from d's
Concept	Identifying a 747 as a jet aircraft
Rule	Calculating the square root of 3.14
Problem solving	Formulating a rule for predicting unemployment level from economic indices

We are most interested here with the last three types or categories.

A concept refers to a class of objects, things, or events which share certain attributes or characteristics. The verbal statement enumerating the attributes which define the concept is called a "definition," in the same sense as definitions found in the dictionary. The standard test of whether a person has mastered the concept is not whether he or she can state the definition or name of the concept, but whether he or she can identify examples belonging to the concept class. The student is shown something and must indicate "Yes, this is an example," or "No, this is not an example" of the concept.

A rule involves the interaction or manipulation of two or more concepts, e.g.) calculating the volume of a sphere or making the noun of a certain class plural by adding the suffix s. Such an operation is often called a "rule" or "principle" in the literature. Sometimes the more lay term "procedure" is used. Applying the rule to a specific instance is often called "rule-using." An example showing how the rule is correctly applied, generally in a step-by-step manner, is called an "example" of the rule. A statement describing a rule, listing what must be done at every step of the manipulation, is called a "rule statement" or sometimes simply a "rule."

A concept is really a special type of rule. For a person to decide whether an instance is a member or example of the concept class, he or she must make sure that the instance exhibits the characteristics or attributes which define the concept. For example, to decide if a 747 is a jet aircraft, one must answer the questions, (a) Does it have airfoil-shaped wings?, (b) Does it fly?, and (c) Does it have jet engines for propulsion? If the answers are "yes," then one concludes that a 747 is a jet aircraft. This process of matching attributes of the instance and the definition is itself a procedure or rule, though it may often be executed in a split second. Applying such a matching rule results in a binary conclusion, "Yes, it is an example," or "No, it is not an example." Other than concept rules, most rules do not have a binary output, but can result in many possible outputs, depending upon the specific instance.

It is because a concept is a special kind of rule that the term "rule statement" (or "rule" for short) is used in conjunction with concepts as well as rules. In the research literature dealing with the discovery and expository methods of instruction the term "rule" generally is used to refer to the rule statement of either a concept or a rule. This usage will be followed in this paper, unless otherwise stated. When the designation "rule/principle" is used, it will refer specifically to a rule, not a concept.

Problem solving behavior is often regarded as the highest category of behavior in the cognitive domain. This refers to situations in which the student is required to solve a problem by selecting, combining, and/or generating rules and then applying the rules in such a way as to solve the problem. Problem solving behavior thus involves "rule-finding" and "rule-using" behavior. In order to qualify as problem solving behavior in the strictest sense of the term, the student must not have known one or more of the rules beforehand (although the teacher may know them). Thus, though we may speak of "practice exercises" or "problems" which the student must solve (e.g., mathematical problems), if the student knows the rule for solving the "problem," it is not really problem solving but rule-using behavior.

Expository Method

Since the discovery method arose in reaction to the then prevailing system of instruction, it may be useful to first define the principal characteristics of traditional expository instruction.

Admittedly, expository instruction may and can take many diverse forms, but one might characterize expository instruction, at least in context of this discussion of methods, as instruction in which the teacher supplies the student with all the necessary information or content that is to be learned. The emphasis is on the conveyance of relatively complete, well organized and defined content. Other terms that have been applied to this variety of instruction are "didactic," "deductive," and "teacher-centered" instruction.

Such instruction has typically provided the student with explicit statements of the concepts or principles to be learned (i.e., the "rules"). Definitions for concepts would be provided as well as procedures for performing a task or exercise. Students may, for example, be required to solve a set of algebraic formulas, but would first be given the rules by which such formulas could be solved. The usual sequence in expository instruction would be first, a presentation of the rule, then manipulation of examples. In instructional literature, this sequence is sometimes referred to as "ruleg." Teacher-presented examples may or may not be followed by practice exercises, examples that the student must manipulate, but such practice exercises are generally included in the more effective forms of expository instruction.

Discovery Method

Just as expository instruction can take many forms, the term "discovery method" has been applied to many different varieties of instruction. There has been a lack of agreement in the educational literature on the definition of discovery learning. Definitions tend to focus on the necessity of the student discovering what is to be learned, without being given the explicit information or content by the teacher. The student is seen as receiving little or no guidance while wrestling with the material and he or she must "go beyond the evidence" to discover something. Just what the student discovers depends upon the specific instructional or experimental situation, but frequently includes the underlying but unstated rule which is illustrated in examples presented to the student. In some cases, the student is actually required to formulate and state verbally the definition of the concept or statement of the principle, but regardless of whether that verbal formulation is required or not, the student must typically be able to apply the rule in new situations, e.g., by solving a similar mathematical problem, or by identifying a new example of the concept that was illustrated by the previously encountered examples.

Other terms have been used to refer to discovery learning, for example, "inductive" method, "heuristic" method, "activity learning," "guided discovery," "egrule" strategy, "learner-centered instruction," and even the term "problem-solving."

The term "inductive" method tends to be used by persons who have less familiarity with the theory and research literature of discovery learning, and is perhaps best to avoid because of additional meanings beyond the concept of discovery learning. The term "inductive" is used in philosophy to identify inductive logic as opposed to deductive logic. Even in philosophy inductive logic is nowhere near as well articulated or defined as deductive logic.

Some psychologists also use the term to refer to inductive processing, i.e., a mental process of arriving at conclusions from a restricted set of data. Although this meaning does have some relationship to discovery learning, it is clearly outside the domain of this paper to explore the mental processes of learners. Rather, the focus is on instructional strategies, what the teacher can do to facilitate learning by the student. In any case, it is difficult to accurately assess and describe and draw generalizations about the internal cognitive processing of individuals or groups. It is easier to describe the techniques that an instructor uses in an effort to get students to learn, and to assess the learning outcomes. Admittedly, Bruner was hopeful of focusing on learning <u>processes</u> rather than learning <u>outcomes</u>. He or other educators could, of course, posit all sorts of learning processes; but what can effectively be described is the set of teacher behaviors and the stimuli presented to the student (these are <u>instructional</u> variables) and the <u>outcomes</u> of instruction--what skills or knowledge the student is able to demonstrate. Research on the discovery method thus tends to focus on the instructional variables and the outcomes of instruction, rather than the process.

Another term used to refer to discovery learning is "egrule," an abbreviation for "example-rule." This simply means that learners are first given examples before

formulating or seeing the rule statement. A sequence of rule, then examples would be termed "ruleg."

The term "problem-solving" is sometimes used synonymously with discovery learning. In one sense this is true, since the student is not shown the rule-statement but must discover it; the "problem" is to discover the rule. This type of problem solving, however, is not the usual kind of problem solving, which typically is more complex and requires the student to discover or find many different rules, often each of them known to the student in isolation, and combine them together in a strategy--a new rule--to solve the problem.

In "guided discovery" the learner is not provided certain information, but is guided by the instructor with hints, questions, or other devices to find the rule. In a "pure" discovery situation, no such help would be given.

In analyzing the senses in which the term discovery method is used and ways in which it is operationalized in research designs, it is possible to define discovery method in terms of two variables:

1. Amount of guidance
2. Sequence of rules and examples

In a pure discovery mode, the student is given no guidance from the teacher, but is expected to discover the underlying rule. In expository instruction the student is provided all of the context to be learned and considerable guidance, including, of course, the rule. In discovery learning, the amount of guidance may actually vary from none or a minimal amount to a substantial amount. Guidance can take many forms. Rule statements for the rules and concepts may in one sense be regarded as guidance to help the student master the rules and concepts. Other guidance may take the form of prompts or cues designed to help the learner focus on relevant stimuli and see certain inherent patterns. In some cases the patterns can be highlighted simply by the spacial relationship and placement of the information in the instructional materials. Guidance may also take the form of

instructions or directions designed to help the learner approach the instructional task in a certain way. Objectives, advanced organizers, inserted questions, or a variety of other devices can also be given as guidance to help the student focus his or her attention on important information or skills. Feedback or praise or encouragement can also be regarded as forms of guidance.

The second variable which frequently characterizes the differences between expository and discovery instruction is the sequence in which critical information is given the student, specifically, the sequence of rules and examples. In expository instruction, the student is first given rules, then examples which illustrate the rule. After that, the student is generally given practice exercises in which he or she must use the rule in specific instances. In the discovery method, the student is first given examples and/or practice items which illustrate the rule, from which he or she must induce the rule. Upon formulating the proposed rule, the student would generally be given either feedback or the rule-statement to confirm the discovery.

Given all of the variables mentioned above, research on the discovery method is expectedly diverse. The practical effect of this is that the body of research tends to be somewhat inconclusive. However, a significant portion of the research includes the manipulation of rules and examples and their sequence, so that in this portion of the research literature it is more possible to reach some conclusions.

It is important to keep in mind that the discovery method has generally been addressed in the theoretical and research literature as an alternative to expository instruction, and therefore in opposition to it. The two varieties of instruction are thus treated as two polar concepts, and much of the research dealing with them compares the two. Much of the research appears to be motivated by a desire to substantiate the claims and superiority of the discovery method.

In actual instruction, and even in research design, it is sometimes somewhat difficult to distinguish the two approaches in a pure way. Much instruction is actually a combination of the two. For example, take the sequence of instruction, examples-rule-examples. The first part of this sequence, examples-rule, reflects the discovery method, whereas the latter part of the sequence, rule-examples, reflects the expository approach. Even in a discovery mode, once the student infers the rule, feedback or the actual rule is often given the student, after which the student is expected to apply the rule to new situations instances. At that point it is inaccurate, strictly speaking, to talk about a discovery mode, since the rule has already been discovered. If, moreover, the student is given no practice items for applying the rule, the instructionl sequence will probably be faulty and not result in student mastery of the rule, i.e., application of the rule.

Another reason pure polar types of instruction are not prevalent is because even in discovery learning there is a range in the amount of guidance a student can be given in his or her attempt to discover the rule. Many research designs have in fact included a "guided discovery" treatment, which shares some of the characteristics of expository instruction. One critic of discovery learning, Ausubel (1978), has even charged that guided discovery learning is simply a form of expository instruction. While being aware of this relative indeterminacy of boundary between discovery learning and expository instruction, it is still useful to look at the research comparing discovery and expository instruction. If there is to be any useful effect of discovery learning, it is most apt to be detected in experiments which distinguish the two approaches.

Rationale for the Discovery Method

Ausubel (1978) summarized the following arguments advanced in support of learning by discovery:

1. All real knowledge is self discovered.
2. Meaning is an exclusive product of creative, nonverbal discovery.

3. Sub-verbal awareness is the key to transfer.

4. The discovery method is the principal method for transmitting subject-matter content.

5. Problem-solving ability is the primary goal of education.

6. Training in the "heuristics of discovery" is more important than training in subject matter.

7. Every child should be a creative and critical thinker.

8. Expository teaching is "authoritarian."

9. Discovery organizes learning effectively for later use.

10. Discovery is a unique generator of motivation and self-confidence.

11. Discovery is a prime source of intrinsic motivation.

12. Discovery ensures "conservation of memory." (p. 520)

Ausubel argues that these claims for the benefits of discovery learning are untenable both logically and pedagogically (Ausubel, 1978, pp. 520, 529-553). Many of Ausubel's arguments are theoretical in nature, appealing to logic or educational philosphy to refute the claims. Some of his arguments seem to lose their power because he takes a rhetorical stance against overstated or exaggerated claims by advocates of discovery learning. However, in all fairness to Ausubel, the claims for discovery learning have often been couched in far more philosophical rhetoric without basing their claims on empirical evidence.

Many of these claims for discovery learning, of course, are basically philosophical. Arguments 5, 6, and 7, for example, reflect the value placed on each child becoming a critical and creative problem-solving individual. This view reflects a value orientation toward thinking, discovery and problem- solving. While Ausubel undertakes to refute the psychological and educational validity of such claims, claiming that the undue preoccupation or obsession with making the individual student a critical thinker ingnores the importance of teaching the student the body of knowledge of a particular subject matter.

Certain other claims for discovery learning which reflect a more empirically based position can be summarized in this manner:

1. Discovery learning results in better retention of information.
2. Discovery learning results in better transfer.
3. The use of the discovery method is intrinsically more motivating for learners than expository teaching.
4. Engaging in discovery enhances the student's problem-solving or discovery skills.

Hypothesis 4, cited directly above, while open to empirical verification, has not often been addressed in research. Some experiments which include transfer tasks are probably aiming at measuring this type of effect.

Research Findings

Research studies to compare the effects of the discovery method and expository instruction have in general been inconclusive. In their summary of a conference on discovery learning, Keislar and Shulman (1966) indicated one of the major problems contributing to the inconclusiveness of the research:

> Examination of both the exhaustive reviews of the literature and deliberations of the conference lead to an inescapable conclusion: The question as stated is not amenable to research solutions because the implied experimental treatment, the discovery method, is far too ambiguous and imprecise to be used meaningfully in an experimental investigation. (p. 191)

Disagreement about the meaning or implementation of a discovery approach is undoubtedly one of the major contributing factors to the inconclusiveness of the research. Thus, empirical studies, even when meticulously designed and conducted, have yielded results which are difficult to compare.

Other factors contribute to this state of affairs, however. Even when there is an experimental definition of the discovery method, there is often a poor research design, leading to lack of control of experimental variables, confounding of variables (two or more factors which may account for differences, but which are used in the same treatment, and whose effects cannot, consequently, be separated), or obscuring factors which are present in both experimental treatments, e.g., teacher's style.

Despite the difficulties, it is possible to draw at least some tentative conclusions about what the research indicates. There are some trends which point to certain advantages of one or the other method and may serve as the basis for further experimentation and/or the initial design of instructional strategies for an instructional system. Let us first look at research findings about main effects, ignoring the question about whether certain types of students or content or other factors modify the effect of the instructional method.

Effects of Discovery Method and Expository Method

There are two main dependent variables which have figured in research on discovery learning: immediate retention and transfer. In a few experiments delayed retention has been one of the dependent measures. Time spent in learning has been another fairly prominent dependent measure, while motivation or affect has been infrequently examined. Here is a summary of the findings of research on each of these variables:

Immediate Retention

Some studies show no significant differences between the discovery approach and the expository. Many studies actually show the expository approach to be superior. Taken as a whole, one could at least conclude that the expository approach tends to be superior to the discovery approach in terms of immediate retention. For advocates of discovery learning, this is obviously a disheartening conclusion.

Transfer

Here again, some studies show no significant differences between the discovery and expository approaches. However, in this area, research tends to favor the discovery approach as being more effective. This is certainly not entirely conclusive, but a fair possibility. Studies measuring the effect of the instructional method on transfer tend to be inconclusive because the studies do not always treat "transfer" tasks alike. Some studies use the application of a learned rule to new instances as the transfer task (rule-using); others use the discovery of a new rule from a set of examples as the transfer task.

Research findings on transfer effects tend to favor the initial experimental treatment most approximating the conditions of transfer. In cases where discovery of a new rule constitutes the transfer task, the initial discovery treatment tends to be more beneficial than an initial expository treatment; in cases where the transfer task requires the application of an already discovered or explicated rule, the expository treatment tends to produce better results on the transfer task. This strongly suggests that the nature of the transfer task should be strongly considered in deciding what the initial instructional treatment or method should be. Carefully articulated objectives should serve to specify transfer as well as immediate retention requirements.

In general, examination of the effects of discovery learning on transfer tasks yields the most promising results for the advocates of discovery learning. This finding has, in fact, emerged from early research literature and been incorporated into the hypothese. and experimental designs of subsequent research.

Time for Learning

Except for a few isolated experiments, the expository approach shows a clear and consistent advantage over the discovery approach in terms of time required for learning; students simply learn faster with the expository approach. This rather clear finding has

BEST COPY AVAILABLE

led some experimenters to suggest that the real research question about the discovery approach is "not whether learning by discovery enhances learning, retention, and transferability, but whether: (1) it does so sufficiently, for learners who are capable of learning concepts and principles meaningfully without it, to warrant the vastly increased expenditure of time it requires; and (2) in view of this time-cost consideration, the discovery method is a feasible technique for transmitting the substantive content of an intellectual or scientific discipline" (Ausubel, 1978, p. 529).

Motivation or Affect

Very few studies address this dependent variable. Proponents of the discovery approach, of course, hypothesize greater motivation and interest for that method. However, because of the paucity of studies addressing this issue, and because the few existing studies do not adequately measure the variable, one cannot conclude that either method is superior on this variable.

Amount of Guidance

A number of studies compare the relative merit of discovery treatments which vary in the amount of guidance provided the student (an independent variable). In general, the "guided discovery" approaches result in better learning than discovery approaches with less guidance or no guidance. Thus, discovery approaches which resemble or approach expository instruction in terms of the degree of guidance tend to be more effective than discovery approaches with less or no guidance.

Verbalization of Rule

Hendrix (1947) hypothesized that the key to transfer is having a subverbal awareness of a rule and that verbalization of the rule is not only unnecessary for acquiring the rule, but is also harmful for the transfer of the rule. She conducted a study (Hendrix, 1947) which reportedly supported the hypothesis: discovery subjects who were not required to verbalize their generalizations retained their generalizations better (after about two

weeks) than the discovery subjects who were required to verbalize the rule. However, Ausubel (1963) takes issue with her conclusions, pointing out that some aspects of measurement, evaluation, and controls reported in her study make her conclusions somewhat tenuous.

Schwartz (1948) suggested a refined form of the Hendrix hypothesis in a study he conducted: "A recently formed concept may be destroyed by the unsuccessful effort to verbalize it" (p. 63). Schwartz's experimental results did support his hypothesis: subjects who were able to orally verbalize the rule correctly were able to apply the rule in another situation, while of those who incorrectly verbalized the rule, most (but not all) were unable to apply the rule correctly in another situation.

Hanson (1967) found no significant differences in the effects of written verbalizations vs. no verbalizations for eighth graders and college students, although the analysis for college students alone favored the no verbalization group. It is significant to note that college students were drawn from an elementary mathematics course, while the eighth graders were drawn from a higher ability group. Ability to verbalize may, in fact, be a mediating factor in such experiments.

In an experiment by Retzer (1969), before subjects were given the experimental task, they completed a programmed unit involving the specification of domains and quantifiers and were thus prepared to give precise verbalizations. Retzer found no significant differences between treatments, and thus no support for the Hendrix hypothesis. An experiment by Sowder (1974) also yielded no support for the Hendrix hypothesis. A noteworthy difference between the Sowder study and the Hen rix study is that Hendrix required precise verbalization of the rule, while in the Sowder study, vernacular statements were accepted if not inaccurate.

Other experimenters (Guthrie, 1967; Kersh, 1962) obtained results that support the Hendrix hypothesis. However, in these experiments, students had to spend extra time learning the rule until it could be verbalized upon request.

BEST COPY AVAILABLE

While it is difficult to interpret with finality the diverse findings about the effects of verbalizations on subsequent applications of rules, it appears that students who are equipped to verbalize a rule, and who actually have attained an accurate perception of the rule, have no difficulty in further applying it. Students who have not gained an accurate perception of the rule, or are unable to verbalize it, seem to have difficulty in applying the rule later. This can possibly be explained by the concept of retroactive inhibition, i.e., that the involvement of a student in a particular task (verbalizing) interferes with the memory of an earlier task.

Ausubel (1978) suggests that "more probably these findings merely show that a relatively clear and consolidated subverbal insight is more functional and transferable than an ambiguous, inept, unconsolidated, and marginally competent verbally expressed idea" (p. 536). Ausubel cites studies which indicate that verbal insights are more transferable than subverbal insights (Spiker & Terrell, 1955; Weir & Stevenson, 1959) and studies showing that knowledge of underlying verbal principles enhances problem solving (Ewert & Lambert, 1932; Gagnier & Smith, 1962). He argues that the articulation of a rule and providing a label for the concept or rule helps the student to remember it and apply it in new situations.

Relationship of Instructional Methods and Learner Characteristics

As individual research studies have failed to yield definitive conclusions about the superiority of the discovery method of instruction over the expository, attention has been increasingly turned to seeking for interactions with various learner and content variables, in an attempt to ascertain what type of learners or what type of content are most beneficially taught by the discovery method or the expository method. First, interactions with learner variables will be discussed.

Mental Ability

Much research fails to establish that mental abilities or IQ affect students' performance under expository or discovery learning conditions. Many studies (Anastasiow, 1970; Barrish, 1970; Fowler, 1931; Krumboltz, 1965; Ray, 1961; Robertson, 1973) have found no significant interactions between IQ and method of instruction, discovery vs. expository. One study (Sobel, 1956) found that subjects with high IQ's showed superior learning results under the discovery method, as compared to the expository method. For subjects of lower IQ, there were no significant differences in performance between discovery and expository method treatments. Maynard and Strickland (1969) found similar significant benefits for high ability subjects, although the strength of the interactions was comparatively weak. Again, among low ability students, the expository method and discovery method yielded equivalent results.

Babikian (1971) found a three-way interaction between sex, IQ, and instructional method: high IQ boys performed better than high IQ girls under the discovery method, with high IQ girls doing no better under the discovery method than the expository. Nevertheless, high IQ boys still did not perform as well in the discovery treatment condition as in the expository. Babikian also reported that on a transfer test, high IQ subjects performed better having received the discovery approach than those having received the expository approach.

Field Dependence/Independence

Some researchers have investigated whether the instructional method--dis-covery or expository--interacts with field-dependence/independence. Field-independent individuals are characterized as being analytical and able to abstract relevant stimuli or attributes from a field of stimuli. Field-dependent individuals tend to approach a situation in a more global fashion and are less able to extract particular stimuli or attributes analytically: their strength is to apprehend the whole situation in an integrated way and also to be more sensitive to people and social situations.

Some researchers have posited that the expository approach is better for field-dependent students, since it provides a more analytical treatment of the learning task rather than requiring students to analyze it. Likewise, field-independent learners are posited to perform better under the discovery approach to learning, since they are able to analyze the learning situation and perhaps even need that challenge.

Of two studies examining this hypothesis, one of them (Douglass & Kahle, 1977) failed to find evidence for the interaction, while the other (McLeod, 1977) did find evidence that field-independent students learned better with the discovery approach and field-dependent students better with the expository approach. However, in the latter study the treatment variables were confounded, the expository group seeing examples in symbolic representation and the discovery group seeing examples in concrete, manipulable form. It is, therefore, impossible to draw conclusions about the interaction of instructional methods and field-dependence/independence.

Aptitudes and Interests

One study (Tallmadge & Shearer, 1969) examined the relationship between what they called "learning styles," instructional methods (discovery vs expository) and the type of learning task or content. To measure "learning style," the experimenters administered a battery of aptitude and interest tests to their subjects, e.g., tests of arithmetic, mechanical, clerical, verbal, logical reasoning, etc.; the Kuder Vocational Preference battery of tests (mechanical, computational, scientific, artistic, literary, social service, etc.); and a variety of other aptitude measures. The experimenters found no significant interaction between the instructional method (discovery vs. expository) and learner aptitudes and interests.

Creativity

One experimenter (Barrish, 1970) administered Torrance's Test of Creative Thinking ("divergent thinking") in an experiment to test the hypothesis that high divergent (creative) subjects would learn better using the guided discovery method, while low divergent subjects would learn better under the expository method. The research study failed to support the hypothesis. At this point, therefore, research is inconclusive in establishing a relationship between creative thinking and instructional method, discovery vs. expository instruction.

Age

In an analysis of various experiments on discovery/expository instruction, Hermann (1969) tried to determine whether the age of learners is a significant factor affecting whether the discovery or the expository method is superior. Hermann indicates that it is difficult to draw any definitive conclusions because of the incomparability of the experimental tasks from elementary school to high school to college, and because of the small number of studies dealing with elementary school children, namely two.

Anxiety

Research by Tallmadge and Shearer (1971) yielded a significant interaction between student anxiety and the method of instruction: low anxiety students learned better under the expository method of instruction, while high anxiety students performed better under the discovery method. While such an interaction is not explicitly examined in other studies, Cronbach and Snow (1969) indicated that they had found repeated hints in the literature about an interaction between anxiety and instructional treatment variables (cited in Tallmadge & Shearer, 1971). It is difficult to interpret exactly what this generalization might mean.

Relationship of Instructional Methods and Content Characteristics

There are a number of ways in which the instructional method may interact with the content. These are each discussed here.

Difficulty of Learning Task

An experiment by Danner (1974) attempted to examine the relative effects of the discovery and expository methods by giving students two different lessons. The study found no significant differences on these treatments, the main effects, but post hoc analysis indicated that one of the lessons was more difficult than the other. A further analysis of the data indicated that the expository method was more beneficial for the lesson of relatively high difficulty, while the discovery method was more beneficial for the moderately difficult lesson. The experimenter reasoned that "it seems logical that the two methods might interact with level of difficulty since they differ primarily in the amount of direction given and the amount of direction needed by a learner would vary with the level of difficulty of the task" (Danner, 1974, p. 83).

Mechner, on the other hand, takes a different position on this question in his review of programmed instruction: "If the concept is difficult for most members of the target population, EGRULE is more appropriate. If the concept is easy for most members of the target population, then the RULEG sequence is more appropriate" (Mechner, 1967, p. 97; quoted in Hermann, 1969, p. 64). It is not clear to what extent Mechner's conclusion is based on empirical evidence.

An analysis of the results of Danner's study (1974) and of studies on language teaching (to be cited later) suggests the following reasoning. If the learning task is difficult and it would be difficult for the student to discover the rule, and if the statement of the rule is sufficiently understandable, then the introduction of the rule should benefit the student in mastering the task, and the expository approach, which starts out with the rule, should be relatively more effective than the discovery method. If

the learning task is relatively hard, as is the case above, but the statement of the rule is also difficult to understand, then introducing the rule may provide little positive benefit to the student in bringing order to the examples, and the student would do as well or better simply having the examples rather than a difficult, confusing rule: in this case the discovery approach would probably be more beneficial than the expository approach.

Difficulty of Transfer Task

A number of studies suggest that as the transfer task becomes more complex, the discovery method gains relatively more effectiveness over the expository method for preparing the student for the transfer task (Hermann, 1969, p. 61). In a study by Scandura (1964), discovery and expository groups of students scored equally well on "routine" transfer problems, but discovery group students scored significantly better on "novel" transfer problems. In another study Scandura found that the performance of the expository group of students on transfer tasks was disrupted to a much greater degree than the discovery group students when the transfer task became more complex. He used the term "complexity" to refer to "the attention to detail required to solve a problem" and the term "novelty" as "the degree to which the R-algorithm had to be modified" (Scandura, 1964, page 156; quoted in Hermann, 1969, page 61).

This suggests that the underlying variable is not "complexity" per se, rather, the degree of similarity between the transfer problem and the original learning task. A number of investigators have, in fact, found this to be true: in cases where the transfer task is similar to the original learning task, the expository method results in better transfer, while in cases where the transfer task is dissimilar to the original learning task, use of the discovery method on the initial learning task results in better performance on the transfer task (Breauz, 1975; Guthrie, 1967; Kersch & Wittrock, 1967; Pease, 1975; Singer, 1977). Breauz (1975) found, for example, that where the transfer task is rule-using, rather than rule-finding or rule formulation, then the discovery approach inhibits

performance. That means that if the transfer task is not a discovery task, then the discovery method on the initial task is not desirable; if the transfer task requires applying the rule initially learned, then the expository approach is better. In examining the effect upon transfer of a "guided" vs. discovery strategy for psychomotor tasks, Pease (1975) discovered that the most effective transfer occurred when the condition of testing on the transfer task was similar to the initial learning strategy, i.e., when subjects receiving the discovery method initially used the discovery method on the transfer task, or initially "guided" subjects received a "guided" transfer task.

These results have great implications in interpreting the designs and results of earlier experiments examining the transfer of skills under discovery and guided learning conditions. In most of the previous studies concerned with transfer, transfer tasks have been administered under the condition of discovery, and thus discovery treatment subjects have generally had an advantage in the transfer task. This raises serious doubts about whether the transfer effects of the discovery method are really greater than for the expository method.

In the Pease (1975) experiment, incidentally, there were two transfer tasks, one of which was judged to be more complex than the other. The results did not indicate that the complexity of the task played a role or interacted with the learning method. Thus, the critical variable is not the complexity of the transfer task, but rather the similarity of the transfer task to the initial learning task.

The real instructional question, then, is "Under what conditions and in what type of transfer task does the instructor want the student to engage?" This should strongly suggest what type of instructional method--expository or discovery--should be used in earlier instruction. If the student is expected to apply rules to new situations, it is likely that the expository approach which teaches those rules would yield better results. If the student is expected to find new rules or engage in problem solving, then this should be

facilitated by providing the student with early exposure to the discovery method. This is in fact, precisely what some advocates of the discovery approach have purported, though not explicitly tested. Kersch and Wittrock (1967) concluded that the merits of a discovery approach for an expository ("directed") approach accrue from what the method requires of students: the discovery method helps students acquire facility in problem solving through the discovery (problem solving) approach, while the expository method helps students apply rules to new situations by giving them practice in applying rules.

The fact that research should bear out this contention represents one of the strongest pieces of evidence for the importance of practice, that a student should engage in practicing the type of skill he or she is expected to perform at a later time. This principle, it would appear, is of profound importance and ultimately is expected to have greater consequence than whether the expository or the discovery approach to instruction is used. If either an expository or discovery strategy fails to give the student practice in performing the required skills, or severely restricts the practice required of the student, then the student's performance in the immediate task or the transfer task is bound to be severely retarded. It also means that experiments which have restricted student practice and manipulation of examples--and this would more typically be the case with the expository treatment--then that experiment is defective and not an adequate test of the relative merits of the discovery and expository approach.

The importance of practice is further emphasized by the experimental results of Chambers (1971). He concluded that "over-learning ,i.e., practicing to mastery and beyond, has a considerably more powerful effect on transfer than does discovery. Over-learning also seems to be an important condition for transfer of a discovered principle--not because the principle is apt to be discovered during over-learning but because a certain amount of practice is necessary to make the discovered principle available for transfer" (pp. 57-58).

Previous Knowledge

Egan and Greeno (1973) conducted a study examining the performance of students under discovery and rule-using (expository) conditions and tried to analyze that performance in terms of component skills. They found that students without mastery of the component skills had more difficulty with the discovery approach, while the rule-using method was effective even with students not having the component skills. In this sense, a rule-using (expository) method compensated for student "deficiencies."

Alterman (1958) found that the inductive method produced significantly better results than the expository method on the transfer test only with students rating low on preliminary background tests, and only on the transfer test. This is consistent with expectations, since in that case students with little background would be having to discover new principles in new material. Students demonstrating a higher level of background knowledge performed better on the initial learning task test and the transfer test after receiving the expository instruction. One could conclude that for students with limited background knowledge or skills, the expository method results in better learning than the discovery approach, unless the objective is to prepare them for later skill in discovery tasks.

Category of Learning in Cognitive Domain

Most of the experiments comparing expository and discovery learning use experimental tasks that are conc pts or rules/principles. At this point, it is not possible to draw generalizations about inte actions between the categ ry of learning in the cognitive domain and the instructional method, i.e., whether the expository or the discovery method is more effective with one or the other of the learning categories-concepts or rules/principles.

The problem-solving category by definition deals with situations where rules are not articulated or known; hence, problem-solving tasks must be approached by "discovery"

methods. To the extent that such problem-solving tasks can be attacked by rules heuristics, they become rule-using tasks and can be subject to discovery or expository teaching methods.

It has already been noted that if the transfer task is a problem-solving task, then the favored method on the initial task seems to be the discovery method.

Memorization tasks do not involve rules or generalizations and therefore are not ordinarily subject to the discovery vs. expository method issue. It is possible, however, to isolate items to be memorized in order to facilitate their memorization, e.g., with the use of objectives, glossaries, italics and other prompts, or through arranging them in patterns which may serve as a help in their memorization. Inasmuch as these devices may be regarded as forms of "guidance," the issue of discovery vs. expository methods may have some implications. Such devices have not been examined in conjunction with memorization tasks in the literature on discovery vs. expository teaching methods, however, and therefore no conclusions can be drawn in this regard.

Domains of Learning

Most of the research on discovery vs. expository methods has been done in the cognitive domain, as already mentioned. A study by Singer and Pease (1979) did use a psychomotor task in their investigation of expository vs. discovery instruction. They used three treatments--a discovery instructional strategy, a "guided" (prompted) instructional strategy (i.e., a "expository" instructional strategy), and a combination instructional strategy (first wi ı prompts and then without). The task was to execute a sequence of hand/foot manipulations of handles and peddles in a pre-determined sequence. The guided learning and combination learning subjects performed better in learning the initial task, but the discovery learning subjects performed better on the one-day delayed retention test. On a transfer task, the discovery learning and combination method subjects performed the best.

Such experimental results are consistent with other research using cognitive tasks. Examination of the experimental treatments suggests, in fact, that the cognitive component of the tasks was more important than the psychomotor component. In an earlier study by Pease (1975), the experimenter does, in fact, admit that the "experimental tasks used in this study certainly involve extensive cognitive effort in the learning of the sequence along with the development of motor skills to manipulate the components" (p. 86). It is worthy of note, however, that the corresponding cognitive task was not a concept or rule/principle, but a serial memorization task--memorizing an invariant sequence of responses.

In Pease's earlier study (1975), the discovery method did not necessarily result in more efficient transfer, contrary to expectations. Rather, transfer was greatest when the testing method of the transfer task was similar to the method of learning in the initial sequence.

In an article by Singer (1977), the author reviews the literature on errorless vs. trial and error learning in the psychomotor domain. He speaks of "trial and error" learning as "discovery learning" and errorless learning as "prompted" or "guided" learning (which is analogous to expository instruction). His review led him to suggest that the instructional strategy be chosen according to the purpose underlying the instruction: a prompted method should be followed if the purpose is to achieve a high level of skill in the learning task (as opposed to a transfer task) or if the eventual performance will be executed in the presence of prompts. If transfer tc other skills must take place, then a discovery approach would be better followed.

Content Areas

An attempt was made to determine whether the discovery or the expository method is of special benefit in particular subject matters. That is a difficult thing to do, first of all, because it's often difficult to determine the actual nature of the experimental

material from the written reports of experiments. Written reports indicate that a significant portion of experimental materials is drawn from the content area of mathematics. Some of these tasks deal with number series which reflect certain systematic arrangements. Other materials to be found in experiments are arrangements or groups of words which express certain relationships, e.g., opposites. Some experiments use coding exercises, requiring the student to decipher cryptograms; these are generated by taking words and scrambling the letters according to various systematic rules and/or substituting letters systematically for other letters.

Most of these types of experimental materials--number series, word relationships, and coding exercises--involve the manipulation of numerical or linguistic symbols, but at a rather rudimentary level. Some of the mathematical tasks are of a higher level, requiring the calculation of products or sums. Other material is clearly drawn from technical fields, e.g., a task involving orthographic projection and a task involving the reading of calipers, a measuring instrument (see Hermann, 1969, for oblique references to content areas.)

The few psychomotor tasks used in experiments involve a fixed sequence of pressing and manipulating various handles, pedals, and other controls by hand and feet.

It is difficult to conclude in what content areas the above experimental tasks can be generalized. However, it is safe to assume that they would have more relevance in the technical and communication fields, rather than in the personal-social area. A review of existing studies on discovery vs. expository teaching methods does not reveal any studies dealing with social content.

There are a limited number of articles which deal specifically with language teaching. These will be considered here.

Language Teaching

Language teachers have for a long time debated the merits of different teaching strategies, including deductive and inductive approaches (Fischer, 1979; Hammerly, 1975). In the late nineteenth century, there was a reaction against the grammar-translation approach, giving rise to the inductive "direct method." While there are some educators who took a more moderate or eclectic approach, advocates tended to be quite polarized into two extreme positions--the one emphasizing the recitation of grammatical rules and explanations, and the other the repeated use of concrete grammatical utterances. The polarization was enhanced by Carroll's dichotomy between the "audio-lingual habit formation theory" and the "cognitive code learning theory" (Hammerly, 1975, p. 16). The "cognitive approach" was simply another name to describe in more modern terms the deductive, traditional method. While Carroll's distinction was probably too polarizing (and he later backed off of such a strong distinction), it did serve to cast in more modern terms an old controversy.

Chastain (1976) carried the distinction one step further, stating that some foreign language educators "feel the basic elements of the audio-lingual and cognitive theories condense to the difference between inductive and deductive learning" (p. 236). Hammerly (1975) feels that Carroll's dichotomy is frankly completely unnecessary, since it is possible to have audio-lingual habit formation with deduction and cognition. For example, Hammerly indicates that:

> A grammatical point can be introduced by means of contrastive examples (calling for cognition on the part of the students), followed by an explanation or generalization (ideally provided by the students themselves, but in any case involving also cognition), followed by intensive habit-forming, choice-making exercises in the performance of which the students apply the rule deductively; however, as these exercises continue and are speeded up, the rule can be gradually phased out from the

students' attention, to be replaced by increasingly automatic responses to structural cues. (p. 16)

This description of a language teaching strategy is consistent with deductive/inductive strategies used in other content areas: the deductive or expository method starting with a rule and continuing with examples, and the inductive or discovery strategy starting with examples, followed by a rule or rules. Hammerly is also quite right in indicating that some strategies have elements of both inductive and deductive methodology, when, for example, initial examples are followed by a rule, followed by additional examples or practice. In other ways, however, the characterization of the inductive approach in language learning departs from the traditional educational definition of inductive or discovery learning. In other content areas, the discovery approach starts with examples but includes a statement of the rule, even if discovered by the students and confirmed by the teacher; in the language literature, the "inductive approach" often is used to refer to a strategy involving only the use of examples, with no explicit reference to the rule. In this sense, it is an incomplete inductive or discovery strategy, but one that is undeniably followed.

A study by Rizzuto (1970) compared the effects of using an inductive and a deductive method for teaching rules of language structure. He used rules of morphology (the structure or composition of words) and syntax (the structure or word order of sentences). His research led him to conclude that the inductive method is superior to the deductive in the teaching of morphological and syntactic rules, measured either by a test on the immediate learning task or a transfer measure. He reasoned that it is logical to expect such results for the transfer test, since transfer tasks are generally inductive in nature in the sense that the rules are unknown.

Beyond that study, however, we are left to theorize under what conditions the inductive or the deductive approach is most beneficial in language teaching. Hammerly (1975) argues that:

There is a middle ground in the deduction/induction controversy. This is to present inductively those grammatical points that the students can learn without an overt rule and deductively with rules, those grammatical points that require such an approach... The grammatical points that benefit from a deductive approach are generally points based on concepts lacking in the native language. (p. 18)

Fischer (1979) suggests this criterion: if the foreign language rule is (a) similar to the native language rule, or (b) dissimilar, but simpler than the native language rule, then an inductive approach would be better; if the foreign language rule is (c) dissimilar and as complex or more complex than the native language rule, then a deductive approach using the rule and making no reference to the native language structure should be used. In formulating such a proposal, Fischer draws upon formulations by Jakobovitz, who designed a transfer model on the basis of the degree of inter-language similarity. Jakobovitz deduced from his model that when two languages are highly similar, the most effective teaching strategy should make use of the student's knowledge of his native language, whereas when the two languages are unrelated, the teaching strategy should ignore the student's knowledge of his native language. This view has some of its roots in the "contrastive analysis" literature, which seeks to identify areas of similarity or difference between a native and foreign language.

At this point, it appears that there are few if any research studies which attempt to establish this proposal. It is not possible to tell from the report of the Rizzuto (1970) study whether the morphological and syntactic structures were relatively similar or dissimilar to the native language of the subjects.

Fischer's proposal is consistent with the findings of other studies about the inductive/deductive strategy variable. The complexity of the learning task has been found to influence whether a deductive or inductive strategy is more desirable: more complex material is in general better taught with the deductive or expository approach. Another

pertinent variable, the similarity of the foreign language to the native language, is analogous to the issue of how much background knowledge or skills the student has before commencing on an experimental learning task. If the student's background is limited or incomplete, then in general the expository approach gives better results. One could argue that initial learning tasks then represent either more complex material or more dissimilar material to what the student already knows.

There are other factors which may affect whether the use of a language rule helps a student learn foreign language structures. If a rule is represented in notation which is unfamiliar to the student, as linguistic rules frequently are, then it may not serve to enlighten the student but to confuse. Even if the rule is parsimonious and accounts for a large corpus of linguistic phenomena, it may be too abstract from the student's viewpoint to be helpful. Another difficulty with some linguistic rules is that they apply to a relatively restrictive set of phenomena or may reflect a generality which has a notable number of exceptions. In such cases, students may find it easier to acquire new structures or patterns through direct exposure to specific instances without being exposed to the rule-statement.

This may also be said for rules in other content areas. If a mathematics rule or physics rule or graphics art design rule is represented in notation or words which are unfamiliar to the student, then the rule-statement is unlikely to help the student understand and apply the rule, but may actually confuse the student. Certainly, if a definition includes terms unknown to a person, then the definition cannot be understood without further elaboration or reference to the meanings or definitions of the component terms. Naturally, the use of examples is one way to overcome this problem, if the examples are intelligible to the person.

BEST COPY AVAILABLE

Career Education

There seem to be no studies pertaining to which method--the discovery or expository method--is better for orienting students to careers and helping them to make career decisions. We are left to extrapolate from other studies under which conditions one or the other method is most beneficial.

Implications and Recommendations for Career Education at NTID

In designing a foundations program, certain decisions need to be made about the curriculum and about instruction. Most of the implications of discovery/expository research deal with the issues of instruction (e.g., instructional strategies), though some have an impact on the curriculum level.

In designing instruction, there are some things we know from research and other things we don't know. We are left to infer, not only from research findings, but from research "trends," instructional theory, logic and experience what approaches may be effective or optimal. We need to make the best informed decisions we can, recognizing that we don't know everything. We need to rely on ongoing evaluation to test and refine the approaches we take. This is a critical recommendation suggested by a thorough review of the literature.

The discovery/expository literature gives some direction for designing instruction, but its conclusions are not definitive. Consistent trends may still be useful to point a direction, however. The following sections will make recommendations for the "best anticipated approach" to instruction. They will go beyond the research data and reflect the reviewer's knowledge of other instructional research and theory. The rationale and source of the recommendations may be found in the preceding sections of this paper. When that is not the case, additional references will be provided.

General Recommendations

1. Do not restrict your teaching approach to either of the "pure" methods, either expository or discovery. Both may be used to advantage, each in different situations. It must also be remembered that few approaches are "pure," but may share characteristics of other methods. Needless to say, it would be a grave mistake to adopt wholesale a discovery approach to instruction, despite the glowing arguments and rationale used to support such a method. Empirical research literature simply does not justify such an adoption.

2. In general, use the expository approach in instruction to promote initial learning and retention. This will result in effective learning in the most efficient time.

3. In general, use the discovery approach when it is important for the student to engage in discovery or problem solving behavior in later, unique transfer situations.

4. In general, give the student as much guidance as needed, e.g., prompts, cues, feedback, praise, etc. Decrease or fade out the guidance as the student increases in proficiency.

5. Design instruction to allow for varying degrees of guidance, depending on the student's knowledge, skills and abilities. Build in some evaluation mechanisms for determining the degree of guidance the student wants or needs.

6. Provide students with opportunities to explore different career options and "discover" how their interests and skills match the career requirements. Some of these opportunities can be structured activities; others must be less analytically structured because of the need for students to "feel" what a particular vocation is like, and whether they like it. In any case, the student/career match cannot be thoroughly dissected analytically, since there are a lot of undefined intangibles which can best be experienced directly.

BEST COPY AVAILABLE

This is not to suggest that career decision making cannot or should not make use of analytical processes to systematically focus on certain variables that need to be considered in making a career decision, nor to suggest that efforts to formulate a systematic approach to career decision making are in vain. To the extent that factors and procedures can be defined and communicated to the student, they can be used to advantage. But it would be a mistake not to provide some opportunities for students to "discover" in more concrete, real or simulated situations, what they as individuals are like and how they feel about particular career options.

Specific Recommendations

These recommendations will specify under what conditions each of the methods--expository and discovery--are expected to give better results.

Expository Method

7. Use the expository approach for concept and rule-using tasks where the rule is definable and the rule can be understood by the student (with examples). One of the critical factors here is whether the rule can be understood by the student. That means that rules should not be so abstract that the student is not familiar with the component concepts, words, or symbols used in the formulation of the rule, or else the rules will cease to have meaning for the student. In some cases, the rule can be made more intelligible by providing definitions of component terms or concepts in words and concepts more intelligible to the student, or by suggesting that the rule is similar or analogous to another rule already understood by the student, or, most commonly, by providing examples which illustrate the rule.

8. Use the expository approach for problem solving tasks where there is a heuristic (an incomplete rule or "rule of thumb") which is definable and can be understood by the student, unless it is judged critical for the student to demonstrate problem solving behavior.

9. In memory level tasks, use whatever mechanisms are necessary or useful to isolate or focus attention on the items to be memorized, rather than letting the student "discover" them. Such mechanisms or devices might include such things as arrows, color high-lighting, lists or glossaries, italics or underlining, objectives, sample test items or study questions, and/or advanced organizers.

10. Use the expository approach for psychomotor tasks where the rule is definable and the rule can be understood by the student (with examples or demonstration).

11. Use the expository approach especially when the efficiency of instruction, i.e., time, is important.

12. Use the expository approach especially on content which is difficult or complex for the student.

13. Use the expository approach particularly in cases where students' prerequisite knowledge and skills are incomplete or faulty. It is important in this case, however, to assure that prerequisite knowledge and skills are described and available to the student.

14. Use the expository approach in conjunction with a discovery approach to provide more examples and practice <u>after</u> a rule has been discovered.

<u>Discovery Method</u>

15. Use the guided discovery approach for tasks for which (a) the rule is not definable or defined <u>or</u> (b) the rule is definable but not easily understood by the student. Such cases may arise where the rule is stated in such abstract or complex terms as to not easily be understood, or is stated in terms of other concepts or words or symbols with which the student is not familiar.

Many linguistic rules may fit into this category, as well as many of the personal/social skills, since the rules governing these skills may either not be definable or, if defined, not very intelligible to the student.

It should be noted that the discovery approach generally provides for the confirmation or statement of the rule once the student has encountered many examples and tried to discover the rule. However, it still may be advisable not to provide the rule to the student if it would not be easily understood.

16. Use the discovery approach when problem-solving behavior in new transfer situations is important for the student to have. This refers to situations in which rules must be selected or found (rule-finding), combined into new rules, and applied to the solution; this does not mean situations where old, known rules must be applied to new situations or instances (rule using). What this in effect means is this: the student who is required to solve problems should be given practice in solving problems; practice is the critical variable.

Besides being given practice in applying rules (rule-using), the student should also be given practice in rule selection (rule-finding) to facilitate problem solving. Instruction and practice in this important skill of rule selection is frequently overlooked. The instructor should make a conscious effort to formulate and articulate a rule or procedure for selecting other rules, including decision points, criteria, and branching logic governing the selection.

17. Use the discovery approach after the student has mastered the defined domain of competencies, when practice in transferring the skills to new situations is desirable. This is simply another way of emphasizing the need for students to acquire problem-solving skills. In sequence of time, this opportunity would probably be provided relatively late in a unit, course, or curriculum.

18. Use the discovery approach to help students gain a "feeling" for career areas, and an awareness and understanding of themselves--likes and dislikes, abilities and limitations, etc. These are factors which are often not definable by the teacher, counselor or student. In any case, give students concrete experience with a proposed

career or major area in order to refine their choices. This will probably come relatively late in the foundations program, after career choices have been tentatively made in as analytical a manner as is possible. The important factor here is not really whether a discovery or expository approach is used, but whether students are exposed to actual "examples" of the concepts inherent in a career decision.

Additional Critical Recommendations

It is important in implementing the preceding recommendations to pay attention to several other related variables which are extremely critical. These will be discussed here.

19. Make a conscious effort to integrate new material with old material already acquired by the student. Both the teacher and the student need to make a conscious effort to make this integration. This is one of the most critically important factors which needs to be accomplished in instruction. It not only makes learning more "meaningful" but it is a key mechanism by which new information is encoded into memory, i.e., "learned." This means that both rules and examples which incorporate elements already familiar to the student may have a positive facilitating effect on learning, while rules or examples which are not intelligible to the student have a disruptive effect. Other devices besides rules and examples may, of course, be utilized, e.g., analogies, heuristics, elaborations, and numerous other devices.

20. Use examples to illustrate concepts and rules. Examples should be used for either the expository or the discovery approach. Whether or not they are used probably impacts on the effectiveness of the instruction more powerfully than whether the expository or discovery approach is used.

21. Require students to practice manipulating the concepts or rules they are being taught. Much instruction is highly defective because of omitting this important component of instruction. The inclusion of practice is probably more powerful than whether the expository or discovery approach is used.

22. Consider carefully the importance of time in designing an instructional program. Efficiency is often a goal of an instructional design, i.e., how a student can learn the most in the shortest period of time. However, some studies indicate a correlation between the time expended in instruction or study and the amount learned (Stallings, 1980). This suggests one goal (a competing goal) of an instructional system is to have the student spend more time on the learning task, not less.

Making a conscious effort to integrate new material with old may take more time than learning something in a rote way. This suggests being careful not to compress learning time unduly, but allowing enough.

23. Use prompts and cues judiciously. The literature on prompts and cues--visual or verbal mechanisms to draw attention to relevant stimuli or expected responses--indicates the value of them in guiding a student to acquire a concept or rule. The research literature also demonstrates the value of fading them (dropping them out gradually) over time as the student progresses from an initial contact with the material toward mastery. This means that students should gradually receive less guidance as they progress through an instructional sequence. This might mean shifting from an expository to a discovery or problem solving approach as they progress through a unit, course, or curriculum.

References

Anastasiow, N., Sibley, S., Leonhardt, T., & Borich, G. A comparison of guided discovery, discovery, and didactic teaching of math to kindergarten poverty children. American Educational Research Journal, 7(4), 493-510, Nov., 1970.

Anthony, W. S. Learning to discover rules by discovery. Journal of Educational Psychology, 1973, 64(3), 325-328.

Beeker, J., & Young, C., Jr. Designing instructional methods in mathematics to accommodate different patterns of aptitude. Journal for Research in Mathematics Education, 1978, 9(1), 4-19.

Blake, K. A., Ainsworth, S. H., & Williams, C. L. Effects of induction and deduction on deaf and hearing individuals' attainment of first-order concepts. American Annals of the Deaf, 1967, 112, 606-613.

Boutwell, R. C., & Barton, G. E. Toward an adaptive learner-controlled model of instruction: A place for the new cognitive aptitudes. Educational Technology, 1974, 5(14), 13-18.

Breaux, R. Effects of induction vs. deduction and discovery vs. utilization on transfer of information. Journal of Educational Psychology, 1975, 67(6), 828-832.

Bruner, J. S. The Relevance of Education. New York: W. W. Norton & Co., Inc., 1971.

Chambers, D. W. Putting down the discovery learning hypothesis. Educat onal Technology, March 1971, 54-59.

Collinge, J. The teacher's role in discovery learning. Reading Improvement, 1975, 3(2), 92-95.

Craig, R. Directed versus independent discovery of established relations. The Journal of Education Psychology, 1956, 47, 223-234.

Craig, R. Recent research on discovery. Educational Leadership, Feb. 1969, 26, 501-505.

Cronbach, L. J., & Snow, R. E. Aptitudes and instructional methods: A handbook for research of interactions. NY: Irvington Publishers, 1977, 311-320.

Danner, D. W. Effects of discovery and expository teaching methods in locus of control on retention and transfer. (Doctoral dissertation, Temple University) Ann Arbor, Mich.: University Microfilms, 1974, No. 7419746.

Douglass, C. B., & Kahle, J. B. The effect of differentially sequenced individualized instructional materials on student achievement in biology. Journal of Research in Science Teaching, 1977, 14(4), 335-340.

Egan, D. E., & Greeno, J. G. Acquiring cognitive structure by discovery and rule learning. Journal of Educational Psychology, 1973, 64(1), 85-97.

Fischer, R. A. The inductive-deductive controversy revisited. Modern Language Journal, 1979, 63(3), 98-105.

Gagne, R. M. Is educational technology in phase? Educational Technology, 1980, 20(2), 7-14.

Gagne, R. M. (Ed.). Learning and individual differences. Columbus, Ohio: Charles E. Merrill Books, Inc., 1967, 1-45.

Gordon, J. R. An instrument to measure discovery and expository presentations. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, April 1979; ED 169118.

Guthrie, J. T. Expository instruction vs. a discovery method. Journal of Educational Psychology, 1967, 58(1), 45-49.

Hammerly, H. The deduction/induction controversy. Modern Language Journal. 1975, 59(1), 15-18.

Hardie, C. D. Inductive learning. Educational Theory. 1975, 25(1), 40-44.

Hendrix, G. A new clue to transfer of training. Elementary School Journal. 1947, 48(1), 197-208.

Hermann, G. D. Egrule vs. ruleg teaching methods: grades, intelligence, and category of learning. The Journal of Experimental Education, 1971, 30(3), 22-33.

Hermann, G. D., & Hincksman. Inductive vs. inductive approaches in teaching a lesson in chemistry. Journal of Research in Science Teaching, 1978, 15(1), 37-42.

Hermann, G. D. Learning by discovery: A critical review of studies. The Journal of Experimental Education, 1969, 38(1), 58-72.

Hirsch, C. R. The effects of guided discovery and individualized instructional packages on initial learning, transfer, and retention in second- year algebra. Journal for Research in Mathematics Education, 1977, 8(5), 359-368.

Hirshfeld, S. F. An examination of methodological problems in a laboratory comparison of learning by discovery and expository treatment. (Doctoral dissertation, University of Minnesota) Ann Arbor, Mich.: University Microfilms, 1974, No. 752106.

Hoagland, C. W. The selection process: The first step of teaching by the inquiry methodology. (Doctoral dissertation, University of Massachusetts) Ann Arbor, Mich.: University Microfilms, 1973, No. 7314647.

Hosen, R. Effective instruction in principles of economics. The Journal of Economic Education, 1976, 7(2), 125-126.

Hurst, J. B. Discovery teaching and increased student motivation. Toledo, Ohio: University of Toledo, 1972. ED 088807.

Ives, L. A. Some notes on Piaget's account of the role of language in intelligent behaviour. Teacher of the Deaf, 1978, 1(2), 8-10.

Kaye, D. B., Hall, V. C., & Baron, M. B. Factors influencing rule discovery in children. Journal of Educational Psychology, 1979, 71(5), 654-668.

Kersh, B. Y. The motivating effect of learning by directed discovery, Journal of Educational Psychology, 1962, 53(2), 65-71.

Kersh, B. Y., & Wittrock, M. C. Learning by discovery: An interpretation of recent research. In DeCecco, J. P. (Ed.) The psychology of language, thought, and instruction. New York: Holt, Rinehart, and Winston, Inc. 1967, 394-402.

Koran, M. Differential response to inductive and deductive instructional procedures. Journal of Educational Psychology, 1971, 62(4), 300-307.

Koran, J. J., Jr., Koran, M., & Freeman, P. Acquisition of a concept: Effects of mode of instruction and length of exposure to biology examples. Audiovisual Communication Review, 1976, 24(4).

Kornbau, H. C. The practical implications of an informal conceptual analysis of the words, inquiry, and discovery as used in contemporary science education. (Doctoral dissertation, Temple University) Ann Arbor, Mich.: University Microfilms, 1977, No. 7713518.

Krieger, E. Shakespearean crossroads: Teaching Shakespeare through induction. College English, 1977, 39(3), 286-289.

Krumboltz, J. D., & Yabroff, W. The comparative effects of inductive and deductive sequences in programmed instruction. American Educational Research Journal, 1965, 2, 223-234.

Kugel, P. Nothing worth learning can be taught. Improving College & University Teaching, 1979, 27(1), 5-9.

Kuhfitting, P. K. F. Learning aids in the classroom: Experimental evidence of their effectiveness. Education, 1973, 94(2), 135-136.

Lewis, J. S. Directed discovery learning: Catalyst to reading in the content areas, Journal of Reading, 1979, 22(8), 714-719.

Loomer, N. J. A multidimensional exploratory investigation of small group- heuristic and expository learning in calculus. (Doctoral dissertation, University of Wisconsin-Madison) Ann Arbor, Mich.: University Microfilms, 1976, No. 7618892.

MacNeil, R. D. The effects of a discovery and expository instructional style upon the change in the learning performance of field-dependent and field- independent undergraduate students. (Doctoral dissertation, University of Iowa) Ann Arbor, Mich.: University Microfilms, 1979, No. 7928595.

Mayer, R. E. Learning to solve problems: Roles of instructional method and learner activity. Washington, DC: National Science Foundation. 1974. ED 091-225.

McDade, C. E. Subsumption vs education set: Im, lications for sequencing Instructional Materials. Journal of Educational Psychology, 19 '8, 70(2), 137-141.

McLeod, D. B., & Adams, V. M. Relating field independence and a discovery approach to learning mathematics: A trait-treatment interaction study. Paper presented at the annual meeting of the American Educational Research Association, New York, April 1977.

Mollett, D. In support of inductive learning. Educational Theory, 1978, 28(1), 62-67.

BEST COPY AVAILABLE

Moody, G. S. The interrelationship of maturation and development upon inquisitiveness in deaf children. Teacher of the Deaf, 1978, 6(2), 190-195.

Nelson, B. A. Effects of analytic-global and reflectivity-impulsivity cognitive styles on the acquisition of geometry concepts presented through emphasis or no emphasis and discovery or expository lessons. (Doctoral dissertation, University of Wisconsin) Ann Arbor, Mich.: University Microfilms, 1972, No. 7231693.

O'Brien, T., & Shapiro, B. Numbers patterns: Discovery vs. reception learning. Journal for Research in Mathematics Education, 1977, 8(2), 83-87.

Olander, H., & Robertson, H. The effectiveness of discovery and expository methods in the teaching of fourth grade mathematics. Journal for Research in Math, 1973, 4(1), 33.

Packer, J., & Bain, J. Cognitive style and teacher-student compatibility. Journal of Educational Psychology, 1978, 70(5), 864-871.

Pascarella, E. T. Interactive effects of prior mathematics preparation and level of instructional support in college calculus. American Educational Research Journal, 1978, 15(2), 275-285.

Pease, D. G. Initial learning, transfer, and relearning of serial motor tasks as a function of instructional strategies as well as task complexity and testing strategies. (Doctoral dissertation, Florida State University) Ann Arbor, Mich.: University Microfilms, 1975, No. 762687.

Pet rson, P. Aptitude X treatment interaction effects of teacher structuring and student participation in college instruction. Journal of Educational Psychology, 1979, 71(4), 521-523.

Prather, D. C. Trial-and-error vs. errorless learning: Training, transfer, and stress. American Journal of Psychgology, 1971, 84(3), 377-386.

Ray, W. Pupil discovery vs. directed instruction. Journal of Experimental Education, 1961, 29(3), 271-280.

Reid, T. G. Differences in creativity on relationships between creativity and achievement effected by the directed discovery and direct detailed teaching methods. (Doctoral dissertation, Arizona State University) Ann Arbor, Mich.: University Microfilms, 1973, No. 7320432.

Rizzuto, M. F. Experimental comparison of inductive and deductive methods of teaching concepts of language structure. The Journal of Educational Research, 1970, 63(6), 269-273.

Roesch, I. H. Analyses of relationships between measures of self-actualization, discovery teaching climate, and selected characteristics of secondary science students in residential schools for the deaf. (Doctoral dissertation, University of Idaho) Ann Arbor, Mich.: University Microfilms, No. 7529949.

Roughead, W. G., & Scandura, J. M. What is learned in mathematical discovery. Journal of Educational Psychology, 1968, 39(4), 283-289.

Sakmyster, D. C. D. Comparison of inductive and deductive programmed instruction on chemical equilibrium for high school chemistry students. (Doctoral dissertation, Indiana University) Ann Arbor, Mich.: University Microfilms, 1972, No. 736993.

Salmon, G. Heuristic models for the generation of aptitude treatment interaction hypotheses. Review of Educational Research, 1971, 42(3), 327-343.

Singer, R. To err or not to err: A question for the instruction of psychomotor skills Review of Educational Research, 1977, 47(3), 479-498.

Singer, R. N., & Gaines, L. Effects of promted and problem-solving approaches on learning and transfer of motor skills. American Educational Research Journal, 1975. 12(3), 395-403.

Sowder, L. Further work on verbalization of discoveries. Journal of Research in Mathematics Education, 1975, 6(4), 223-227.

Sowder, L. The influence of verbalization of discovered numerical or sorting-task generalizations on short-term retention in connection with the Hendrix hypothesis. Journal for Research in Mathematics Education, May 1974, 5, 167-176.

Stefanich, G. P. Eliciting inquiry in earth science. Journal of Geological Education, 1979, 27(3), 111-113.

Stock, S. J. A comparison of abstract deductive and concrete inductive. Improving College and University Teaching, 1975, 23(1), 39-40.

Strike, K. A. The logic of learning by discovery. Review of Educational Research, 1975, 45(3) 461-483.

Tallmadge, G. K. Relationships between training methods and learner characterisctics. Journal of Educational Psychology, 1968, 59(1), 32-36.

Tallmadge, G. K., & Shearer, J. W. Interactive relationships among learner characteristics, types of learning, instructional methods and subject matter variables. Journal of Educational Psychology, 1971, 62(1), 31-38.

Tallmadge, G. K., & Shearer, J. W. Relationships among learning styles, instructional methods, and the nature of learning experiences. Journal of Educational Psychology, 1969, 60(3) 222-230.

Thomas, E. W. A comparison of inductive and deductive teaching methods in college freshman remedial English. (Doctoral dissertation, University of Pennsylvania) Ann Arbor, Mich.: University Microfilms, 1970, No. 7022866.

Thorndyke, P., & Hayes-Roth, B. The use of schemata in the acquisition and transfer of knowledge. Cognitive Psychology, 1979, 11, 82-106.

Tims, E. H., & Ives, L. An experiment in the teaching of Temporal Causal Sequencing Skills with a small group of severely subnormal hearing-impaired pupils. Journal of the British Association of Teachers of the Deaf, 1980, 4(1).

Tobias, S. Achievement treatment interactions. Review of Educational Research Winter, 1976, 46(1), 61-74.

Veiga, J. F. Experiential Learning in Management Education: What Kinds of Students Benefit? College Student Journal, Spring, 1976, 10(1), 62-68.

Vernon, M. Fifty years of research on the intelligence of deaf and hard-of- hearing children: A review of literature and discussion of implications. Journal of Rehabilitation of the Deaf, Jan. 1968, 1(4), 1-12.

Watts, W. J. Deafness, thought and language and the influence of Piaget. Teacher of the Deaf, 1978, 2(4), 117-123.

Weimer, R. C. An Analysis of Discovery. Educational Technology, Sept. 1975, 15(9), 45-48.

White, R. T. Effects of guidance, sequence, and ATI on learning, retention and transfer of hierarchially ordered skills. Instructional Science, 1976, 5(2), 133-152.

Wright, D. P. Interactions between instructional methods and individual aptitudes in the teaching of critical thinking in social studies. (Doctoral dissertation, University of California, Berkeley) Ann Arbor, Mich.: University Microfilms, 1975, No. 7615430.

Yeany, R., Jr. A case from the research for training science teachers in the use of inductive/indirect teaching strategies. Science Education, Oct-Dec 1975, 59(4), 521-529.

Zimmermann, M. J., & Sassenrath, J. M. Improvement in reading and discovery learning in mathematics. Educational Research Quarterly, Spring 1978, 3(1), 27-33.

BEST COPY AVAILABLE